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# Curiosity's Landing Dynamics Observed at the CSIRO Parkes Radio Telescope

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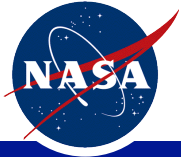
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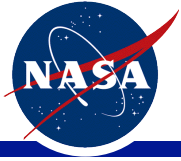


# On 6 August 2012



- Entry, Descent & Landing (EDL) mission phase is very challenging since vehicle autonomously executes critical events
- Acquiring status information is key to understanding the performance of the complex EDL system
- These data may be the only clue in case of anomalies
- Mars Science Laboratory mission operations team successfully tracked the X-band signal as it plowed through the atmosphere, adjusted entry path and powered its descent to its landing site
- As a back-up, Radio Scientists eavesdropped on the UHF signal transmitted from the lander to the orbiter





# UHF! EDL!! DTE!!!



- The CSIRO Parkes Radio Telescope in Australia joined DSN station in Canberra Australia
- Real time knowledge of spacecraft state was provided through Doppler and power levels received by DSN (X-band, prime) and Parkes (UHF, back-up)
- Ability to track rapidly changing signal dynamics and had been demonstrated in preceding Mars missions
  - Well characterized and well understood
  - Ready for use in other missions to other planets





# History



- History of tracking EDL events via radio links not designed for transmission to Earth by Radio Science team:
  - Mars Pathfinder: first mission to re-invent semaphores
  - Spirit & Opportunity relied on X-band DTE (UHF to orbiters)
  - Huygens lost stable S-band signal to Cassini but DWE salvaged by Green Bank Telescope and Parkes
  - Phoenix UHF signal received by GBT (no X-band)
  - MSL!
- **Planning for InSight Mars Landing**
  - **This is why this subject is still important**



# Parkes: Home of “The Dish”



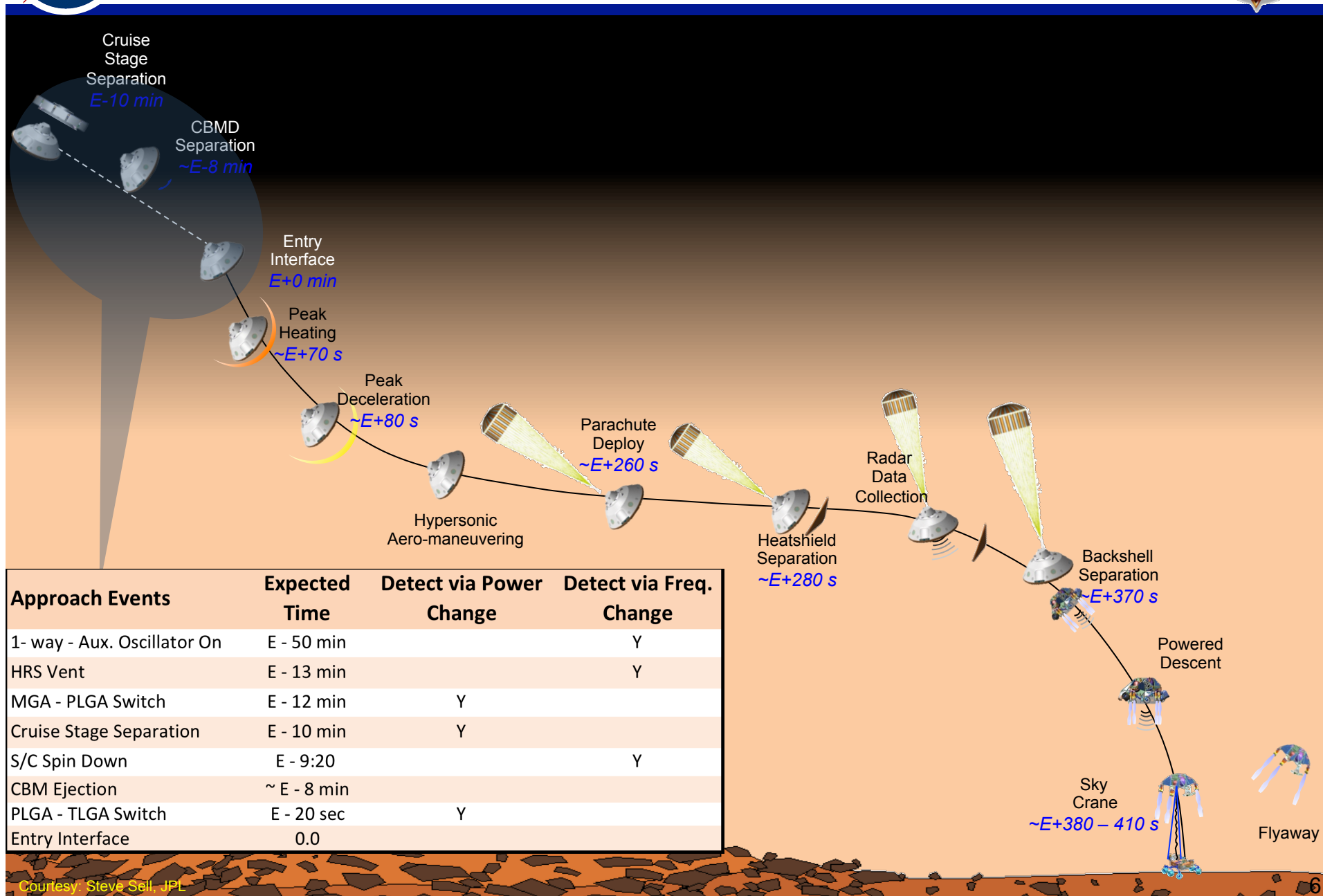
**64-meter  
Diameter**



**Original  
Design  
of DSN**

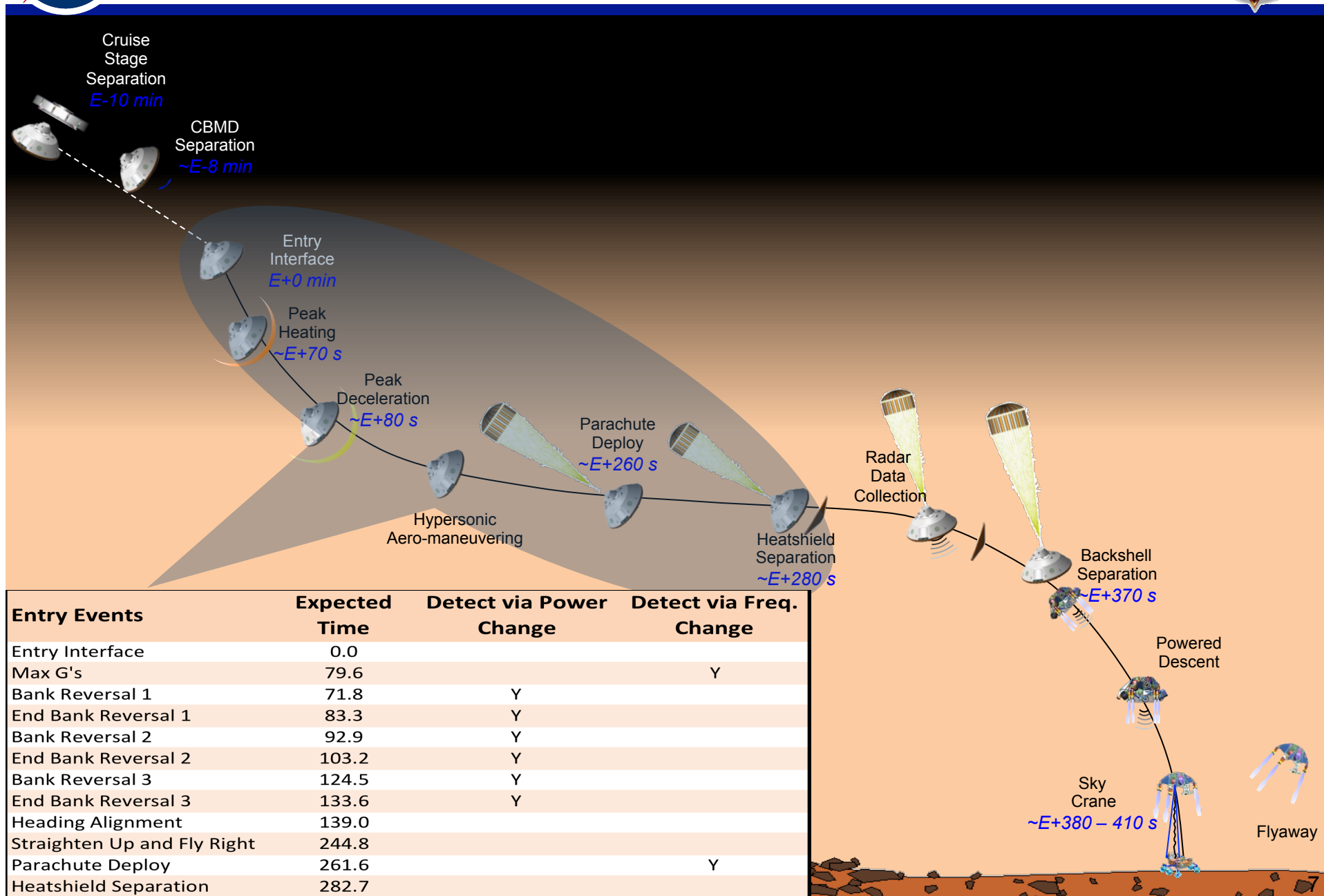


# Approach to Entry



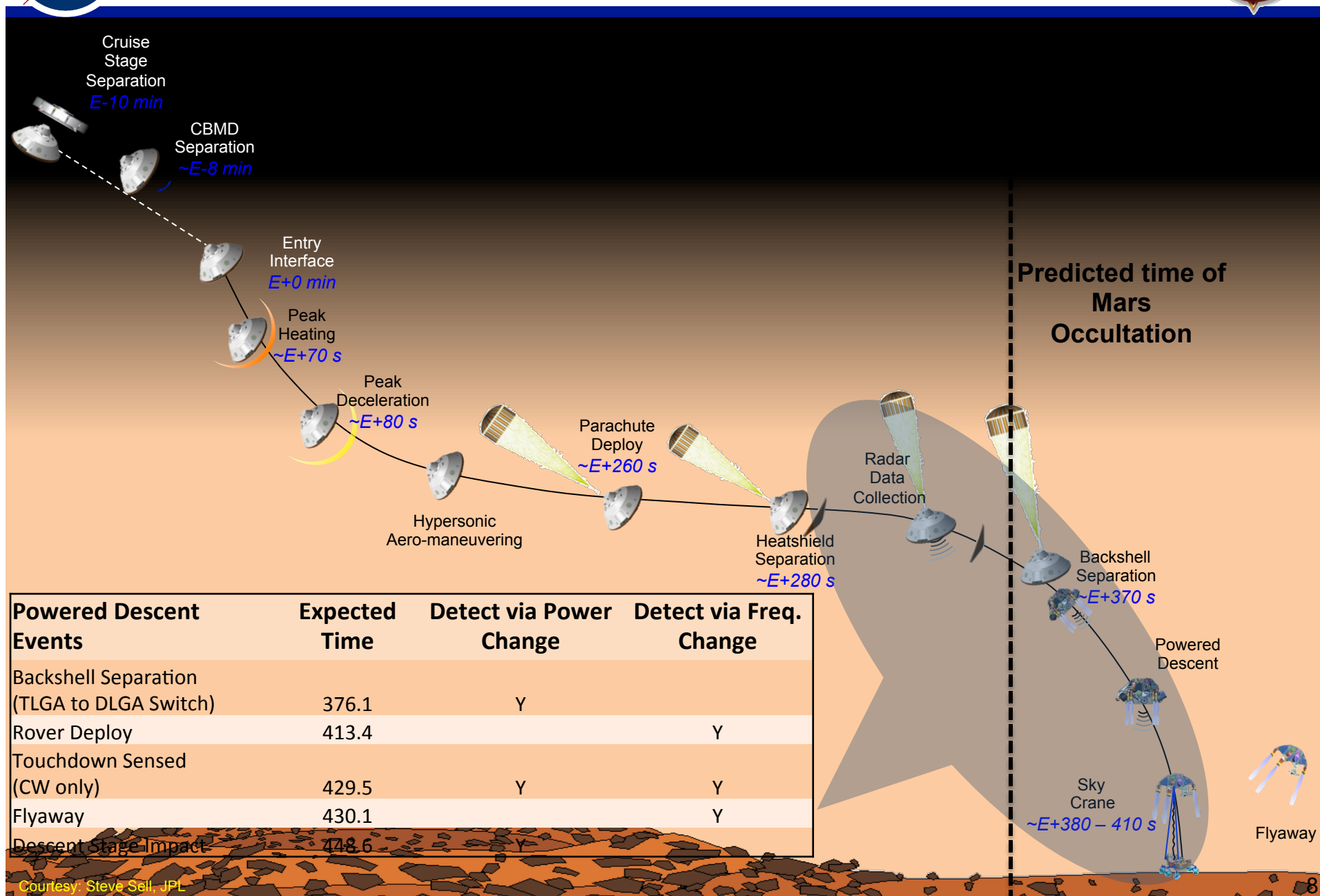


# Entry to Heat Shield Separation



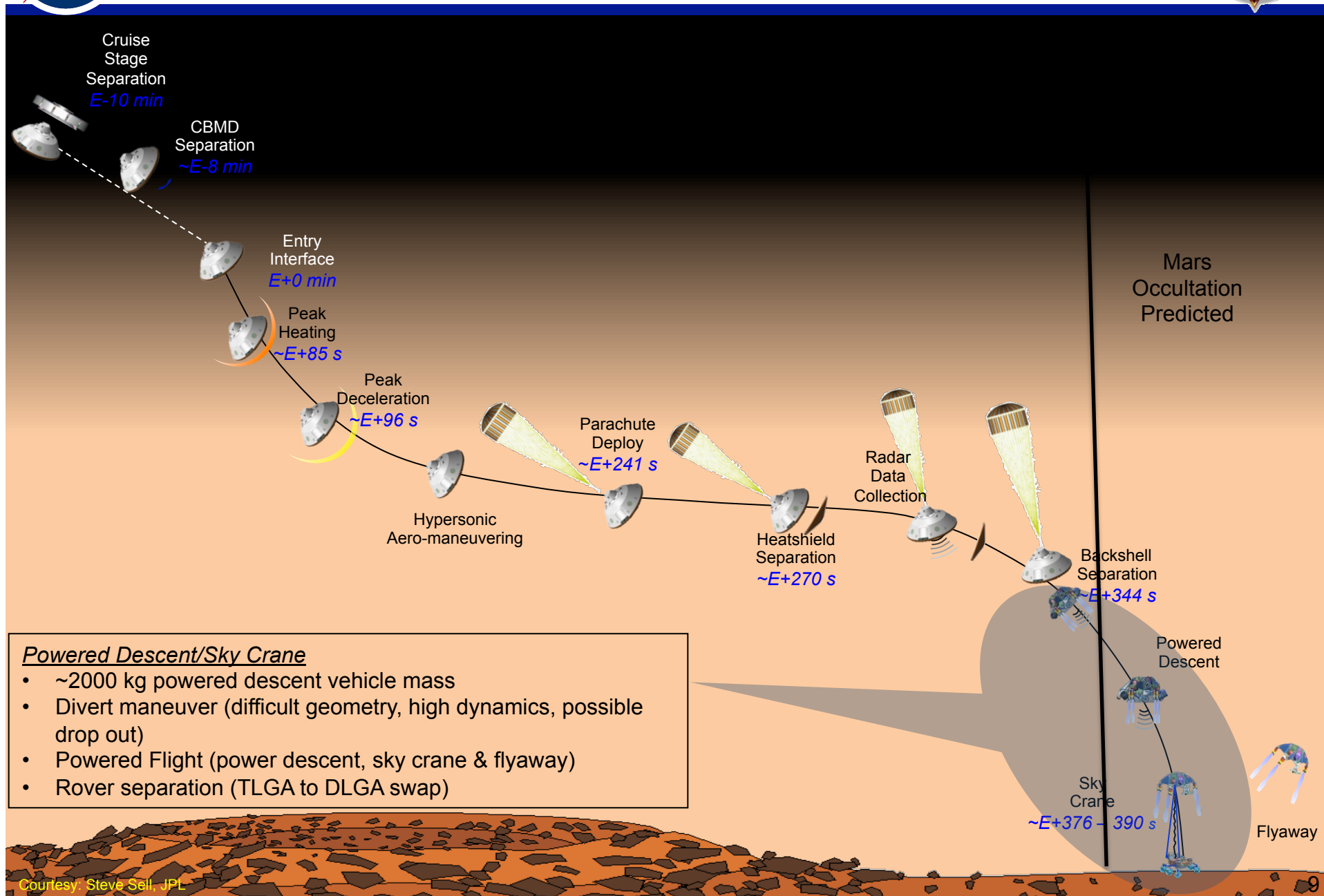


# Heat Shield Separation to Landing



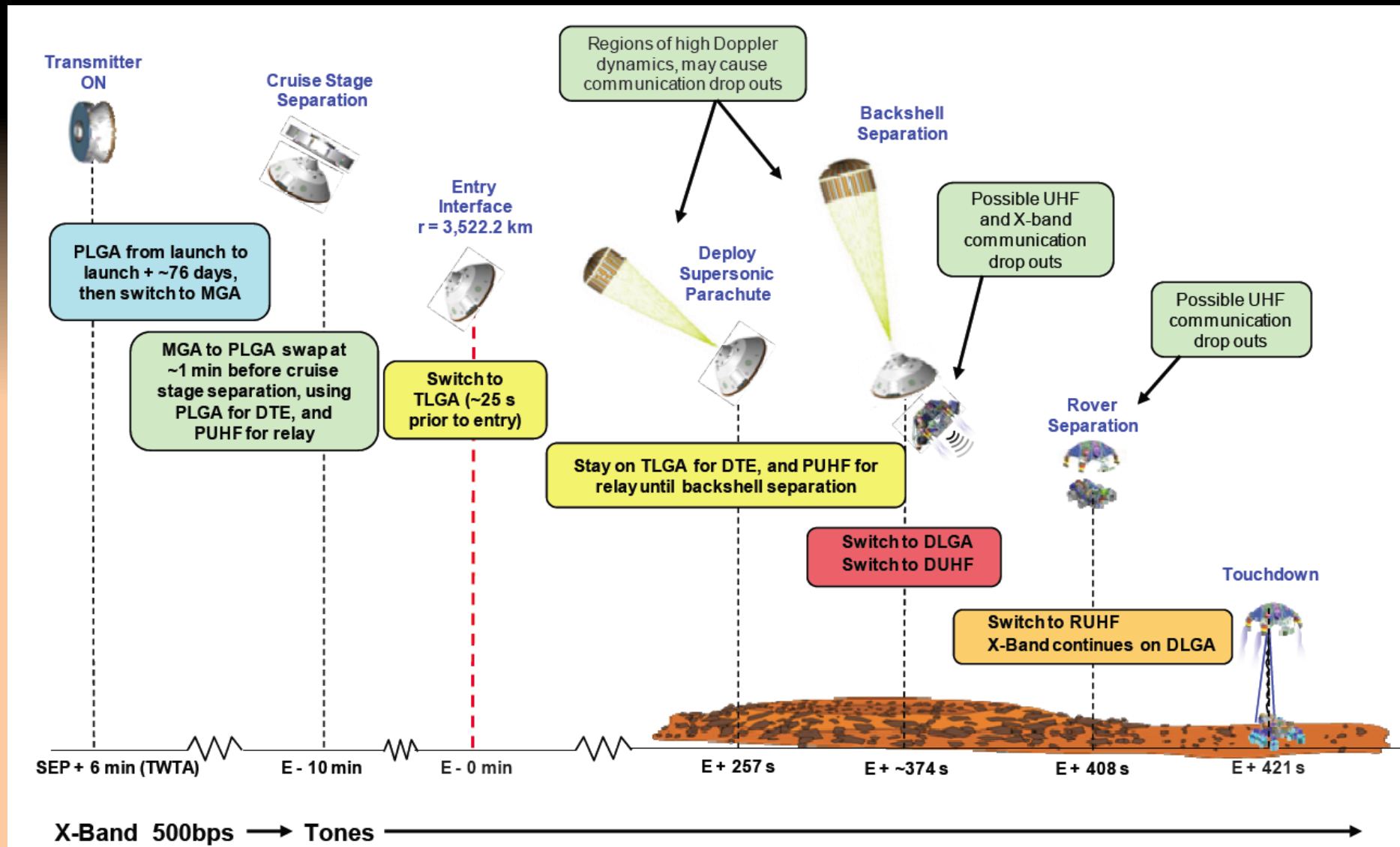


# Powered Descent to Landing



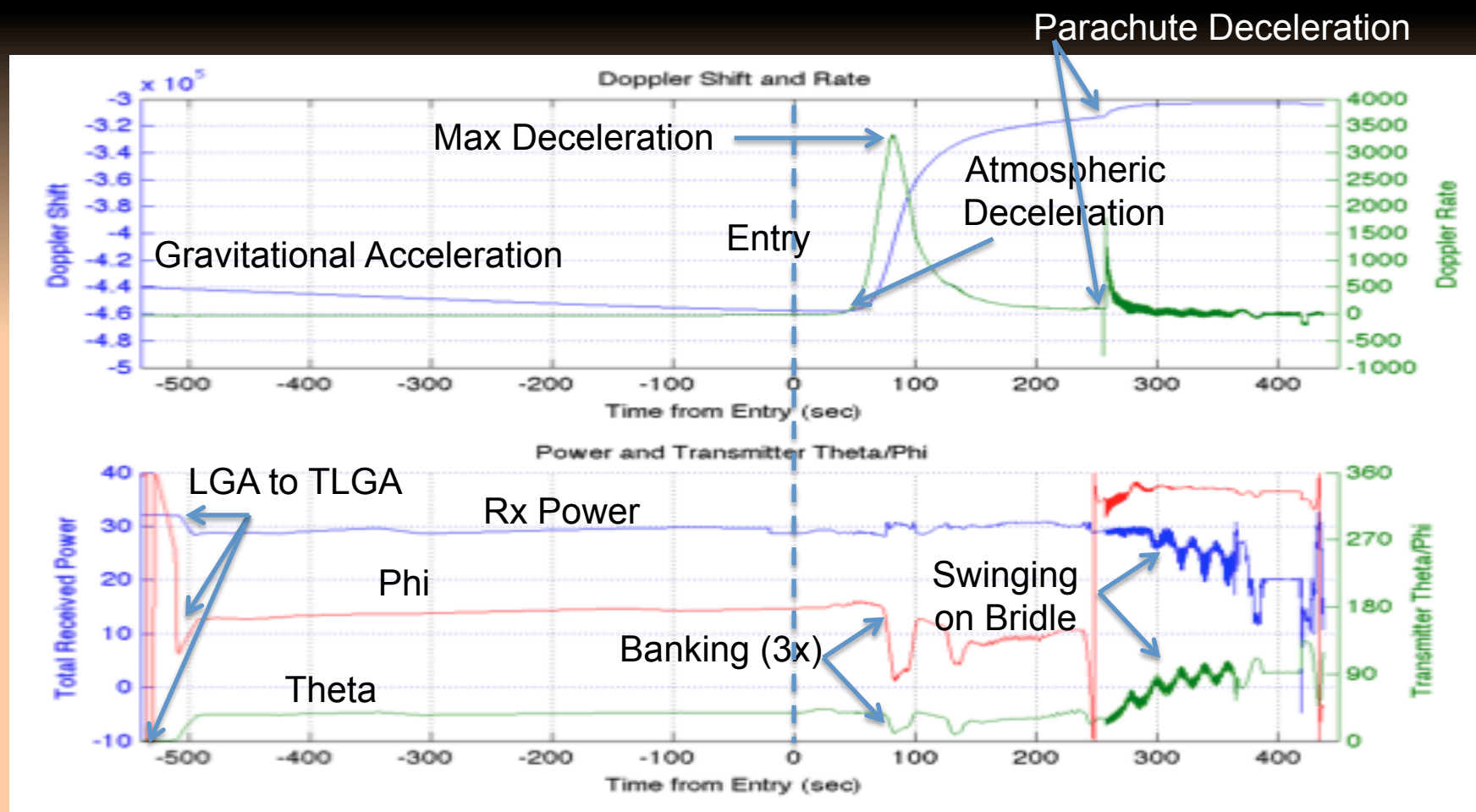


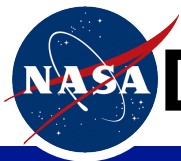
# MSL EDL from Telecom Perspective



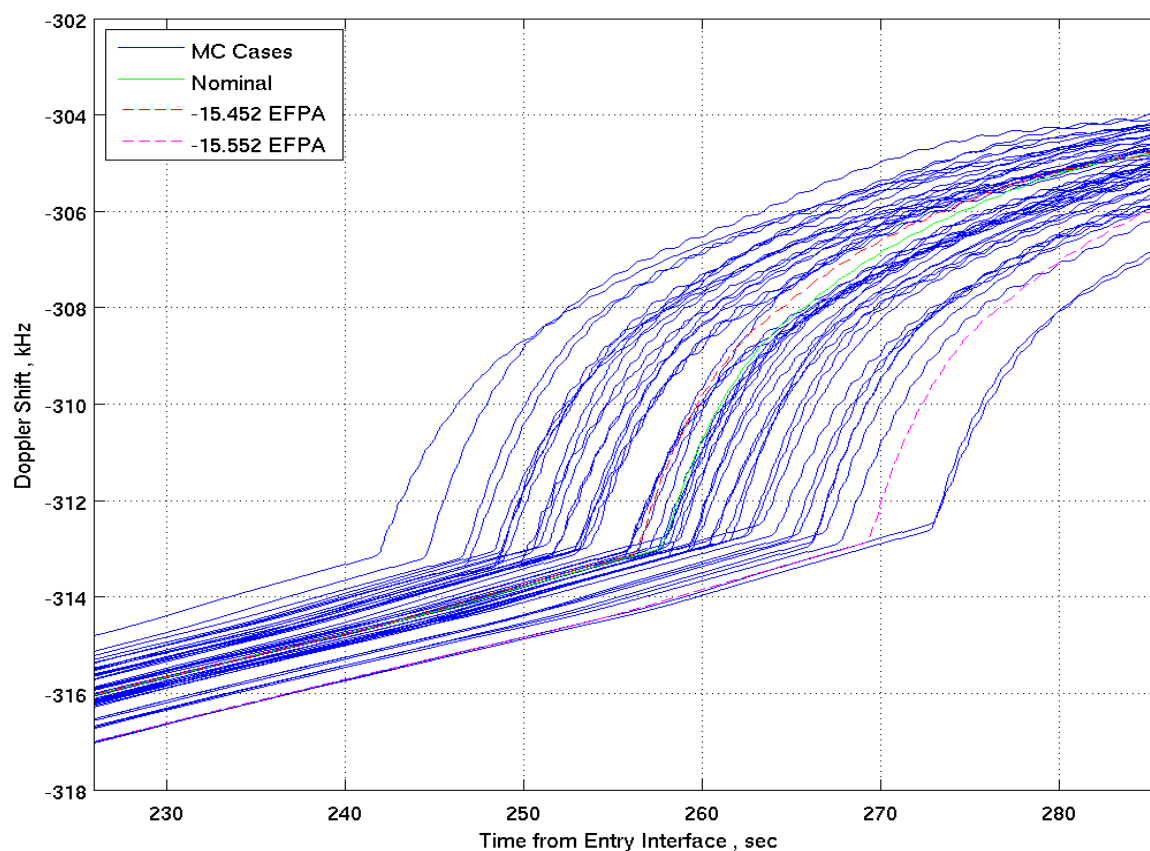


# Predicted Doppler & Signal Power





# Doppler Variation at Parachute Deploy

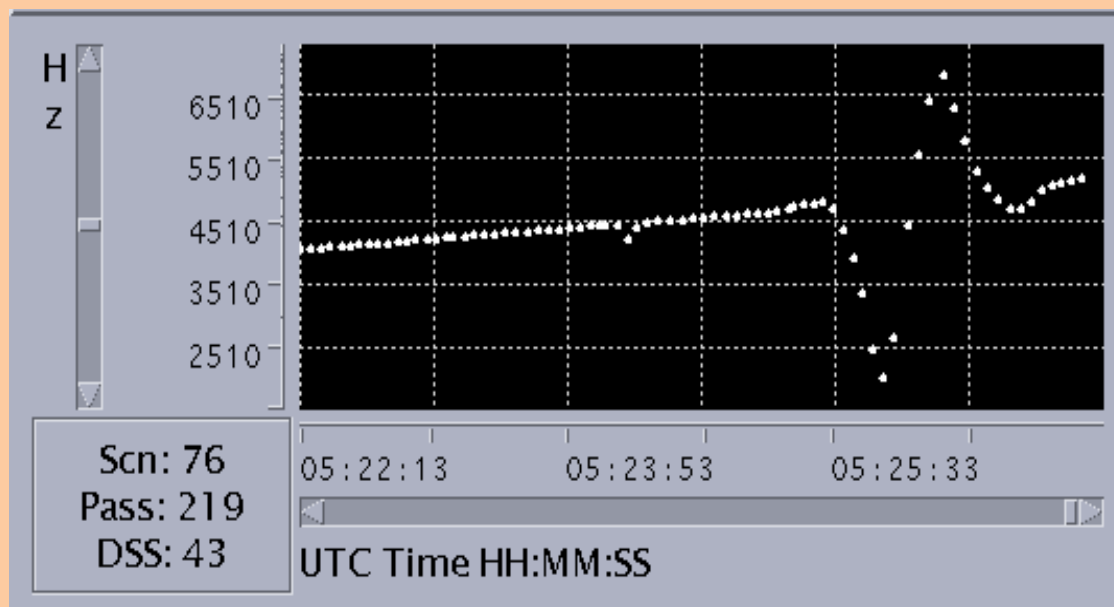
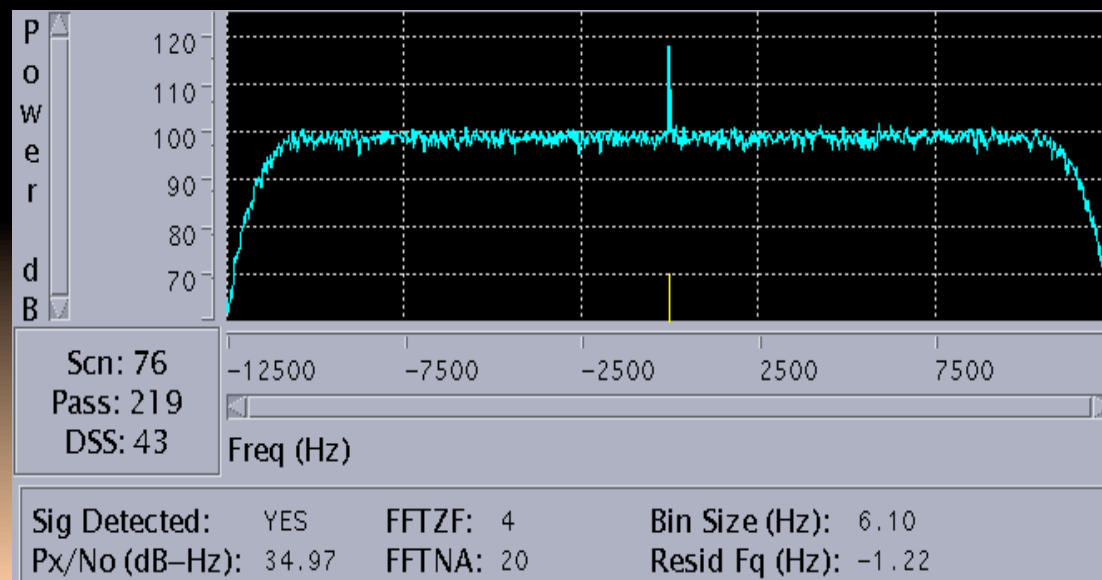




# Radio Science Receiver

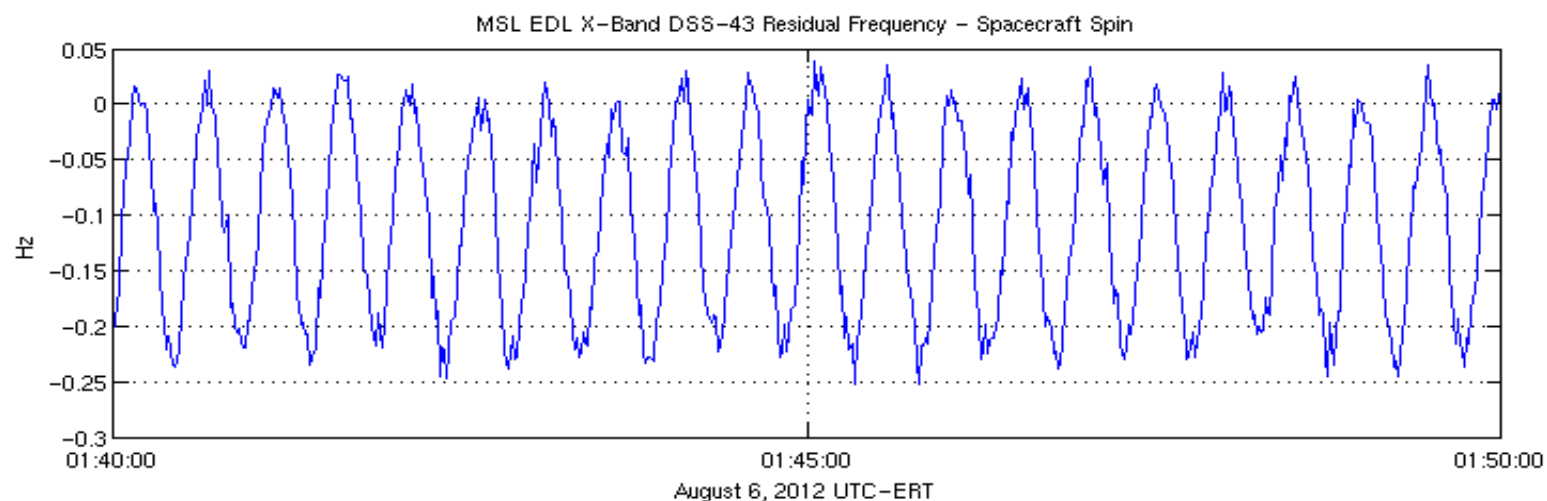
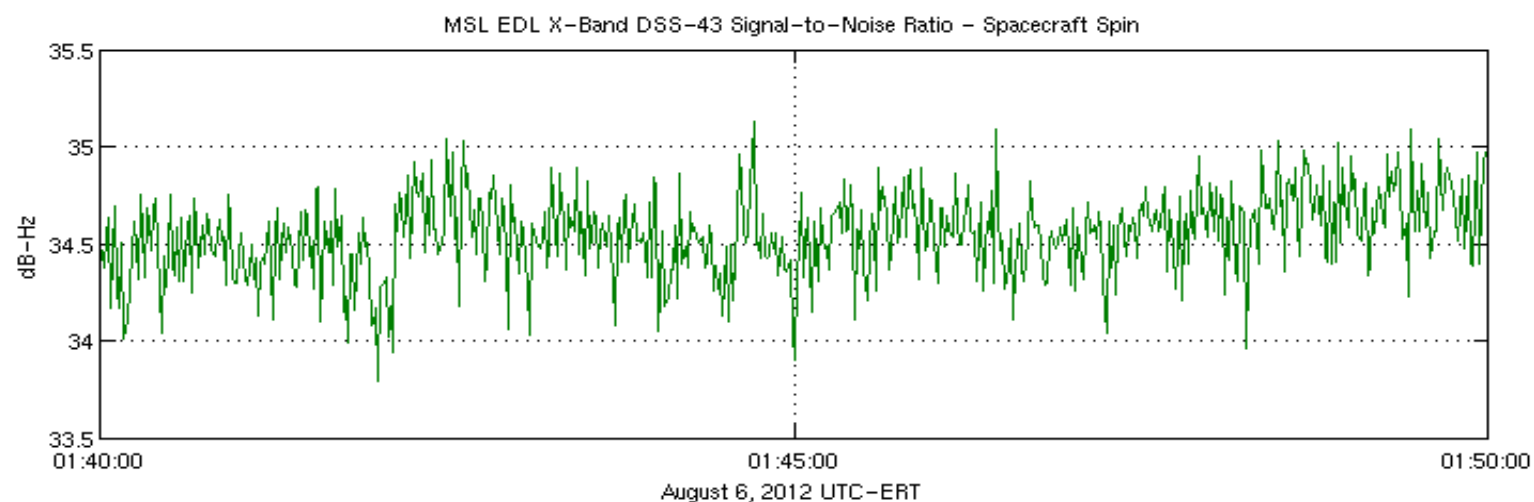


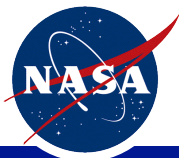
Spectrum of carrier signal prior to cruise stage separation



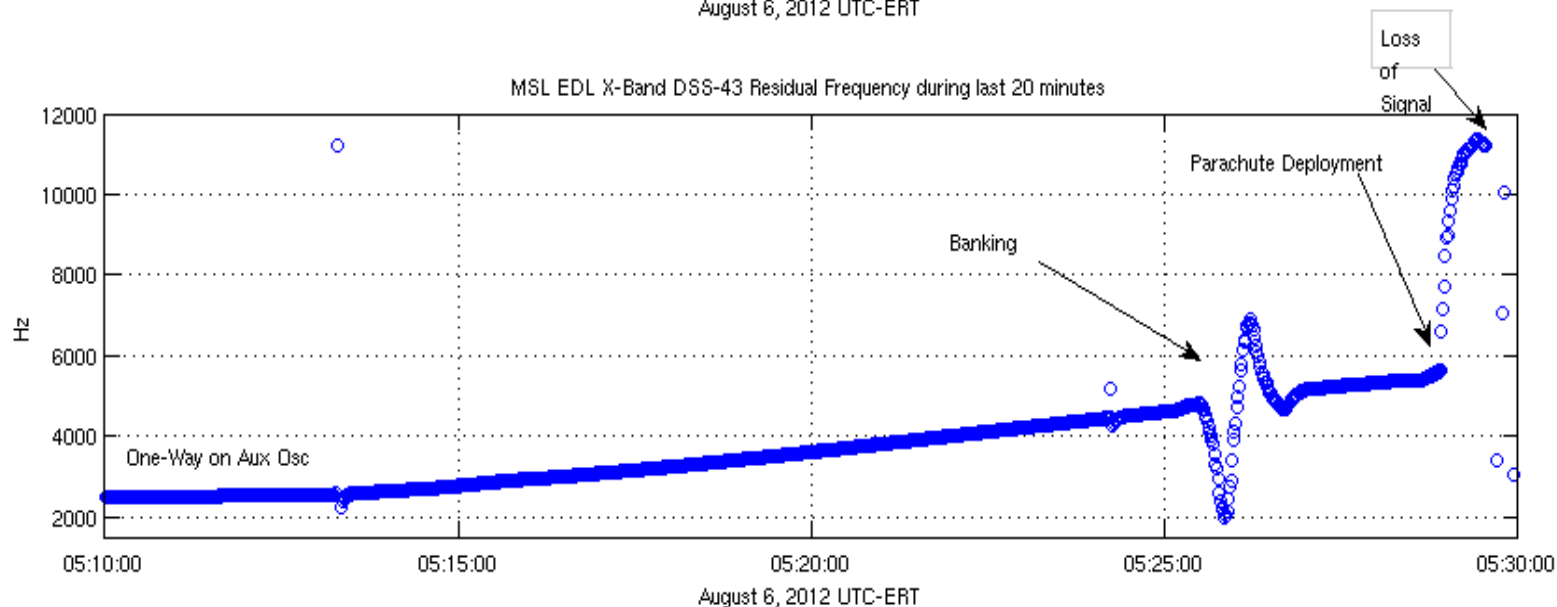
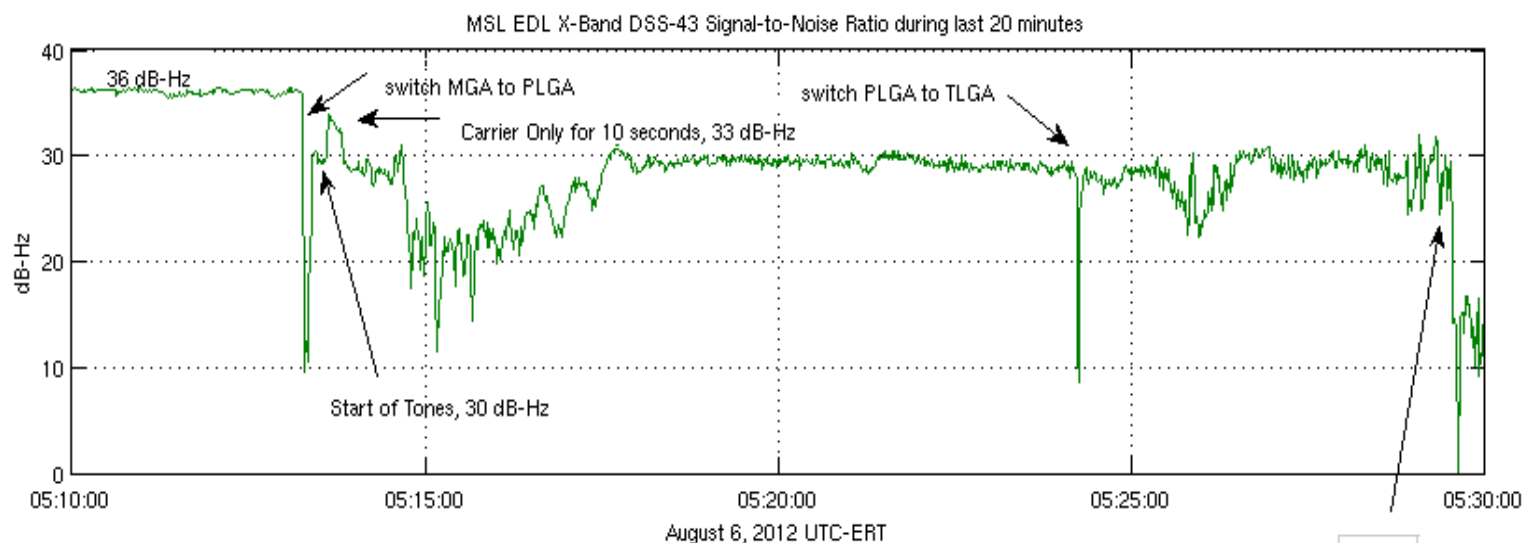


# Spin Signature on Approach



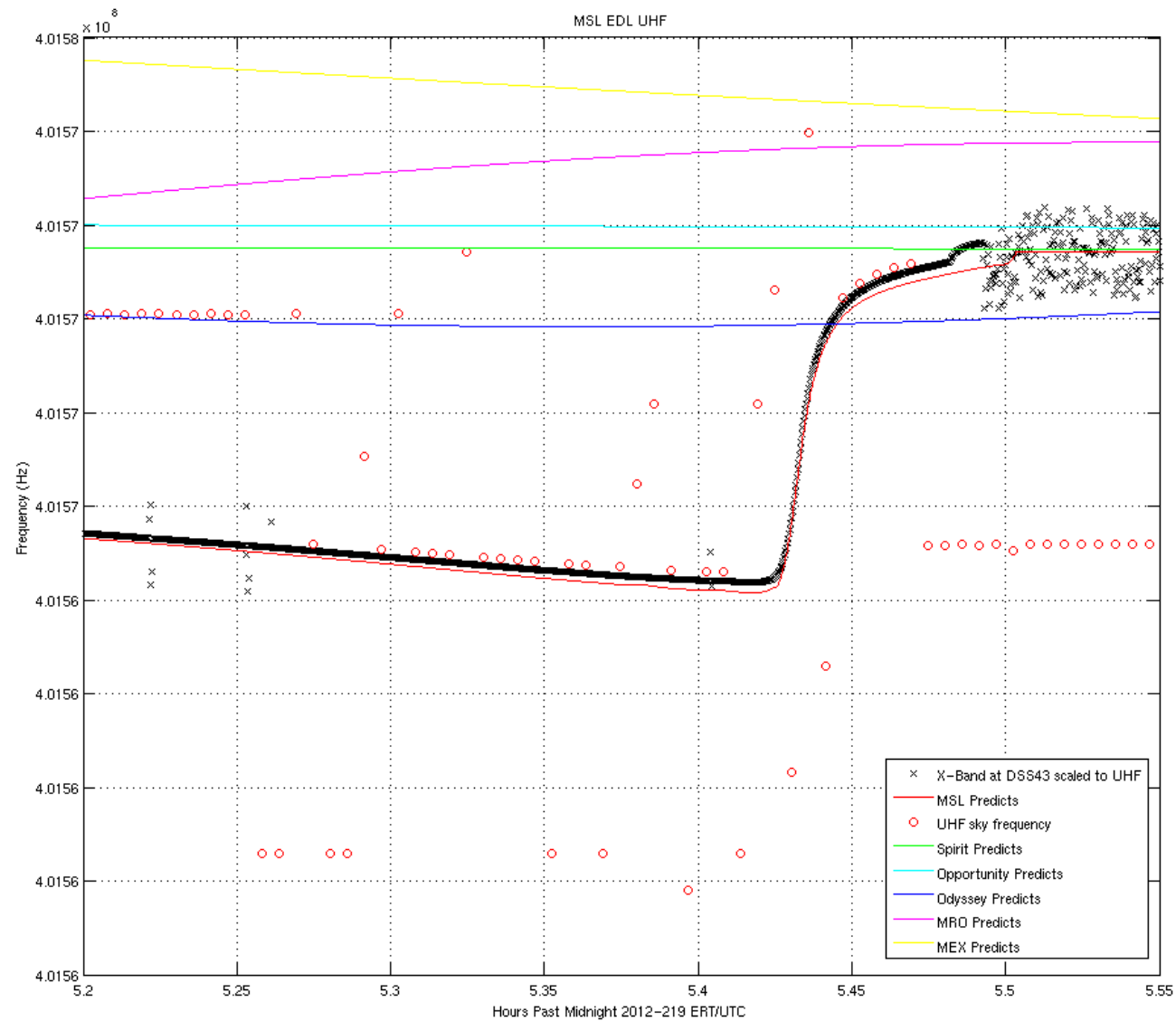


# X-band Last 20 Minutes





# UHF Big Picture





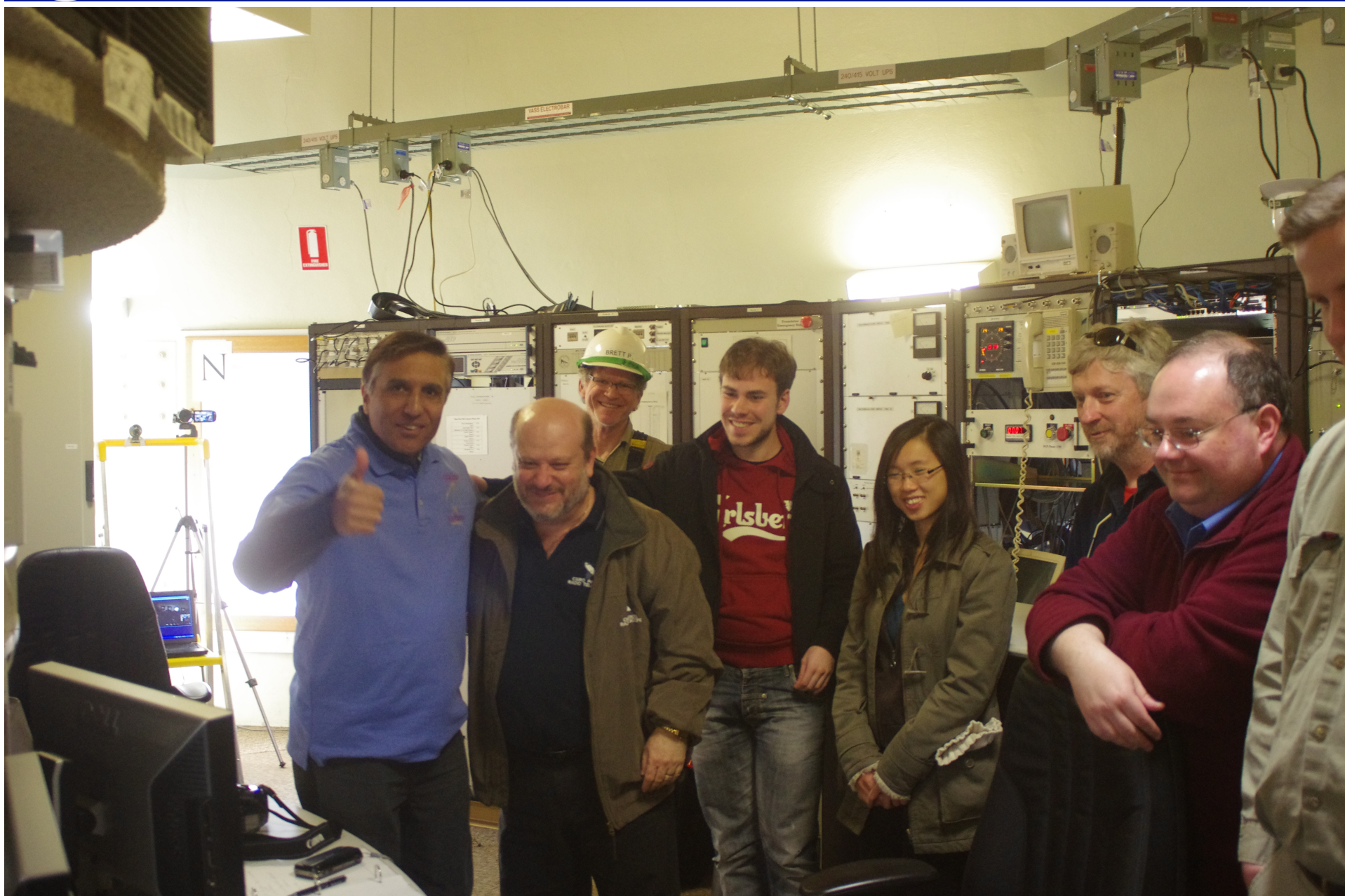
# Conclusion



- Many critical events occurring during MSL EDL sequence detected via the transmitted X-band and UHF signals
- Made accurate evaluation of the spacecraft spin, antenna sequence, temperature profile, and significant dynamic events: guided entry and parachute deploy
- Use of RSR enhanced by Radio Science signal processing techniques effective in determining critical information
- Preparing for future missions.



# Thank you CSIRO





# Nature Smiled on Parkes That Day

